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DEVICE FOR EXAMINING A CONTAINER FOR SURFACE DEFECTS
[Vorrichtung zur Untersuchung eines Behälters auf Oberflächenfehler]

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The invention relates to a device according to the preamble of Claim 1. /1*

Devices and methods of this type are known in general (for example, DE 29 16 361 A1, DE 32 28 010 A1, DE 36 31 973 C2, EP 0 150 846). They are used to examine defects and deformations in or on surfaces of containers, particularly glass bottles or similar articles, where, as a rule, prechosen areas of these containers are scanned with optoelectronic means and examined separately. They include particularly the mouth and threaded area of bottles, and the side walls of containers of all types. For reliable recognition of surface defects it is here above all important to have a clean representation of the area to be examined or of a chosen zone thereof on the image taking surface of the camera, particularly an image taking tube or a CCD image recorder (CCD = Charge Coupled Device). If the representation is poor, or if the light beam used for scanning has an excessively large cross section, small defects in the surface are barely noticed, even if for that purpose evaluation algorithms are used, which are known from the above-mentioned documents and in part very complicated.

The reproduction techniques that have been used predominantly to date provide, for example, in the area of an annular bottle mouth, for focusing the light by means of a ring lamp on the bottle mouth in such a way that, in the case of an intact or undamaged bottle, only the light reflected by the margins of the bottle mouth reach the imaging array, light reflected from the margins of the bottle mouth reaches /2
the imaging array [sic; repetition], while the light that is reflected by a annular zone, which is also called a sealing lip, and which is located in between, is not reflected toward the imaging array. Therefore, as long as the bottle mouth is undamaged, two concentric, bright rings appear on the imaging array, between which a dark ring is located, which corresponds to the sealing lip. If, in such an arrangement, the light, on the other hand, is incident on a defective section of a bottle mouth, for example, a section that presents a tear or a broken out part, then the light is also reflected in

* [Numbers in right margin indicate pagination of the original text.]

the area of the defect under some circumstances at least partially toward the imaging array, which results in the rings present there receiving a concave or convex or similar deformation and/or the dark ring receives a bright spot. These irregularities are determined by measurement technology, and they can be processed for the generation of an error signal that indicates a defective bottle.

All these devices and methods present a decisive defect, namely that only those defects result in deformations of the annular image or other pattern expected for a "good" container that lead randomly to a reflection angle that reflects the light to the imaging array. All surface defects that lead to other reflection angles or reflection angles that are unchanged with respect to an intact surface can therefore not be detected by the known methods. In addition, the ring-shaped zone corresponding to the sealing lip is relatively broad and thus the probability is relatively large that actually present defects are not observed. Corresponding defects result independently of whether the sealing lip in the individual case is planar or arched, or whether other areas of a container besides mouth areas are examined.

The same applies in principle also to the examination of containers for defects with the help of other known devices and methods that work with light of different color. Here, the wavelength of the light, is adapted, for example, to existing container contours, certain markings or defects (DE 34 13 027 A1, US Patent No. 4 650 326), or, in the case of transparent containers, light of different color is used simultaneously for so-called bright field or dark field illumination, in order to be able to simultaneously detect different types of defects (EP 0 387 930 A1).

By comparison, the problem of the invention is to improve the devices that have been mentioned in /3 the introduction in such a way that the chosen area of the container or a selected zone thereof can be verified more reliably than in the past and in this way a verification can be conducted to determine that the detection of surface defects is less dependent than in the past on these randomly generated reflection angles.

The characterizing portions of Claim 1 are used for the solution of this problem.

The invention provides the advantage that the same area is illuminated with light having two or more colors and also from different directions. As a result, the areas to be verified can be examined completely independently of each other with two or more completely separate optical systems. Alternatively, the examined area can also be subdivided into different zones, where each zone is assigned to one of these systems or all the zones are acquired simultaneously by all the systems. In each case, the reliability in the case of the detection of surface defects can be increased substantially. Overall, the invention provides an examination concept that can be used in many applications, and that opens numerous new application possibilities.

Additional advantageous characteristics of the invention are obtained from the secondary claims.

The invention is explained in greater detail below in connection with the drawings in the appendix using embodiment examples. In the drawings:

Figure 1 shows a coarsely schematic front view of a device according to the invention for examining a container for surface defects;

Figure 2 shows an enlarged representation of a detail X of Figure 1;

Figure 3 shows an expected representation of a scanned area of the container in an imaging array in the case of an intact surface;

Figure 4 shows a representation of the container area shown in Figure 1 in the case of a defective surface; /4

Figure 5 shows a view corresponding to Figure 1 of a second embodiment example of the device according to the invention;

Figure 6 shows a coarsely schematic top view of a third embodiment example of the device according to the invention for examining a bottle wall;

Figure 7 shows a front view of the device according to Figure 6; and

Figure 8 shows schematically a side view of a bottle that is in the examination phase in the case of the use of the device according to Figures 6 and 7, where, however, the other device parts are omitted.

The device for examining the container 1 for surface defects, here a bottle, which is represented in Figure 1, is used especially for the verification of the mouth area 2 or the mouth of the bottle. The area 2 consists as a rule of a ring surface, which surrounds an inlet or outlet opening, represented with a broken line 3 in Figure 2, and which, in the embodiment example, is flat at its top side 4, but could also present a convex arch.

According to the invention, the area 2 is irradiated with light from three directions respectively under three angles of incidence, with respect to a middle or rotation axis 5 (Figure 1) of the container 1. As indicated schematically in Figures 1 and 2, an elimination station is used for that purpose that has three light sources 6, 7 and 8, where the illumination with light occurs under a first angle of incidence respectively from a first direction with the light source 6, under a second angle of incidence with the light source 7 and under a third angle of incidence respectively from a third direction with the light source 8. In addition, according to the invention, the light of the first light source 6 has a first color (for example, red), the light of the second light source 7 has a second color (for example, green), and the light of the third light source 8 has a third color (for example, blue), which differs both from the color of the light source 6 and also from the color of the light source 7. In any case, all three colors can be located in any preselected wavelength range.

As shown particularly in Figure 1, the light sources 6, 7 and 8 are arranged on both sides of the /5
axis 5. This is intended to show that the light sources 6, 7 and 8, in the case of the examination of the annular area 2, consist preferably in each case of ring lamps that are coaxial with respect to the axis 5, particularly, for example, ring-shaped fluorescent lamps, or rings that are assembled of circularly

arranged luminescent diodes, where each one of these lamps has a different radius and can be arranged at another height, with respect to the top side 4 of the container 1, to achieve as a result the different directions respectively angles of incidence.

Above the bottle mouth 3 and below the light sources 6, 7 and 8, a scanning station 9 is arranged, which is provided with a light sensitive imaging array 10 (Figure 1), which is preferably coaxial to the axis 5, and which serves to scan the light that is reflected by the bottle mouth. The imaging array 10 consists, for example, of the imaging array surface of a camera that presents an image taking tube or a plurality of CCD sensors that are arranged in columns and rows. To detect the different colors, three different imaging arrays 10 respectively cameras with preconnected filters can be used, for example, filters for the red, green and blue area, or their complementary colors. Alternatively, it would however also be possible, particularly when using CCD sensors, to use only a single imaging array 10, whose sensors are covered, for example, in such a way with color filter films that in each case three adjacent sensors form a segment that is sensitive for all the colors present. The reflected light then has a consequence that the imaging array 10 delivers analog electrical signals that correspond to the brightness and/or color values of the light, where the signals can be evaluated for each color according to one of the known evaluation algorithms, for example, those explained in the documents indicated in the introduction, with which the person skilled in the art is familiar and which therefore do not need to be explained further.

The three light sources 6, 7 and 8 according to the invention are arranged relative to each other and to the area 2 to be swept-scanned in such a way that light of all three colors is incident on in each case one ring-shaped zone with another diameter, and in the case of an intact surface 4 respectively in the case of intact mouth surfaces forming the three zones (Figure 2), in each case, forms a color circle on the

imaging array 10, where the three circles generated also present different diameters. In the ideal case, the light of the three colors is directed at such angles of incidence respectively from such directions on /6
the area 2 respectively the three zones thereof in such a way that three concentric rings 14, 15 and 16 (Figure 3) are formed on the imaging array 10 by reflection, which are assigned to the three light sources 6, 7 and 8 and the three zones to be illuminated by them, and thus appear in a corresponding color, as indicated in Figures 2-4 by means of different cross hatchings for the light bundle that is sent out by the light sources 6-8 and reflected by the area 2.

Figures 2 and 3 show moreover that, in the embodiment example, the three light sources 6-8, respectively rings 14-16 in each case are assigned to another ring zone of the area 2. In particular, the light source 6 is assigned to an inner ring zone, the light source 7 to a middle, and the light source 8 to an external, ring zone of the area 2. As a result, practically the entire area 2 is irradiated with light that, in the case of an intact surface respectively in case of a "good" bottle, is reflected toward the imaging array 10. In the process, with the help of ring-shaped apertures that are not represented and associated with the light sources 6-8 as well as by the position and the diameter of the light sources 6-8 one can fix the relative position that the three rings 14-16 on the imaging array 10 assume with respect to each other, as well as their width (Figure 3).

If the surface of the area 2 of the container 1 is damaged, as shown in Figure 2 using an exemplary defect 17 in the form of a disruption, then one gets for the associated light bundle, here of the color green, a reflection disturbance, which has the consequence that the reflected part 18 of this light bundle no longer fully reaches the imaging array 10 or does not reach it at all. The image of the light source 7 is therefore interrupted at least partially, as indicated in Figure 4 by an interruption 19 in the associated ring 15.

The described procedure in the embodiment example presents, on the one hand, the advantage that the complete area 2 is represented preferably simultaneously on the imaging array 10, and therefore deflected by the defect 17 and therefore scattered light resulting from the defect 17 or another discontinuity is deflected away from the imaging array 10. On the other hand, the three rings 14-16 could even partially overlap because of the different colors, without any risk of failing to detect the interruption 19 in the evaluation. Indeed, even if the same defect 17 would reflect the light of another /7
color accidentally precisely in the introduction 19, the defects 17 would nevertheless be detected, because, in this case, the evaluation reveals that the ring 15 in the area of the interruption 19 presents another color than the one assigned to it.

For example, if it is desirable to examine only selected zones of a certain container area, for example, an inner and an outer zone, 2a and 2b, respectively (Figure 5), of the mouth area 2, then, in Figures 1 and 2, the middle light source 7 could be simply omitted, as indicated in Figure 5, and the again ring-shaped light sources 6 and 7 could be aligned and arranged in such a way that the one (here 6) illuminates the inner zone 2a and the other (here 8) the outer zone 2b of the mouth area 2. In a process, because of the different colors, two separate scanning systems are obtained for the same area 2, which can be adjusted and adapted independently of each other, for example, with regard to the angle of impact (incidence), the intensity, the color, etc. The same applies if the area 2 over its entire width is detected only with two or with more than three light sources, or if the light rays of at least two light sources are directed on identical zones within the area 2, for example, in the middle zone 2c in Figure 5. As a result, with the help of the different angles of incidence or directions, one could ensure that a defect is detected with high probability even if the light of a certain color, due to a randomly produced angle of incidence, is not deflected or is not deflected as strongly by the imaging array 10, as indicated in Figure 2 for the light bundle part 18.

Overall, the result is thus that the invention opens multiple and reliable possibilities for the detection of surface defects, where, in each case, several light sources participate in the detection of the same defect type within the preselected area.

The invention is not limited to the examination of the mouth area 2, which is explained using Figures 1-5, rather it can be used on surface areas of multiple types. Thus, for example, analogously to the mouths, it is also possible to examine immediately connected to them the threaded areas of bottles with different colors, from different directions or with different angles of incidence, in order to drawn therefrom conclusions regarding disruptions and other defects in the threaded parts. /8

Finally, in Figures 6-8, a device according to the invention is represented, which is used for the examination of an area 21 of a container 22, which is designed, for example, as a bottle, a glass, or similar article. The area 21 to be scanned comprises here the entire outer side wall of the container 22, where it is assumed that the wall section is cylindrical respectively rotation symmetrical with respect to an axis 23 (Figure 7), although, correspondingly, flat wall sections can also be examined, as well as wall sections presenting a different curvature. The light sources 24-26, for example, for the colors red, green and blue, here form a linear or a stripe-shaped pattern, instead of the shape of a circle, and they are arranged parallel to the axis 23, as indicated schematically in Figure 7, where the illumination, analogously to Figures 1-5, occurs from outside. In particular, Figure 7 also shows that on a side of the container 22, which is in a mirror symmetrical position with respect to the axis 23, a second illumination station could be arranged with corresponding light sources 24a, 25a and 26a, to examine the containers 22 simultaneously from two sides. The light sources 24-26 respectively 24a-26a project in each case on one selected zone of the area 21 to be scanned a pattern of stripes 27-29 that are parallel to the axis 23, present different colors, as indicated in Figure 8 by the different cross hatching, where these stripes 27-28, in the case of an intact surface, form substantially identically shaped, straight lines, but, in

the case of a surface defect, present deformations. This is indicated in Figure 8, for example, by a deformation 30, which would appear on the imaging array 10, and can be evaluated. In addition, Figure 8 shows that with a corresponding number of light sources it is also possible to produce considerably more than only three different colored stripes, and as a result, a larger number of zones of the area 21, which here comprises the entire peripheral surface area, can be examined simultaneously. The term "area" always denotes in the context of the present invention a container section that is to be examined as a whole (for example, mouth, threading, neck, wall, bottom or similar part), whereas the term "zone" denotes surface sections that are located within the mentioned areas and can form, for example, as in Figure 6, only a small section of the entire area 21.

The invention is not limited to the described embodiment examples, which can be modified in
multiple ways. This applies particularly with a view to the containers and their surface defects to be /9
examined, but also to the means used for the examination and to the ring or stripe pattern generated in the imaging array 10, which can also present completely different shapes. Instead of fluorescent lamps or light emitting diodes, one can also use, as light sources, for example, stroboscope lamps and other optical systems such as projection installations, light sources formed from light guides, or similar devices. Here it is also possible to switch the light sources on and off successively, not simultaneously, in order to generate successively on the imaging array 10 three temporally mutually separate, different, color images, and thus prevent, for example, overlappings of the individual color images. In addition, it is clear that the described devices can be combined in multiple ways with container inspection devices that in themselves are known, they can be passed through the container at high speed, to examine, besides the mentioned properties of the container, other properties (for example, residues, soiling, filling level, etc.). At high speeds during the transport of the container, the imaging arrays can here be particularly those of high speed cameras, and, in the case of Figures 6-8, one could also provide for the

container 22 to rotate between two scanning devices according to the invention that are located one after the other in the direction of transport, about the axis 23, to be able thus to detect all the zones of the side wall area 21. In addition, to facilitate the understanding, all the unnecessary parts of the device, particularly an additionally present optical system 31, are not explained individually. Finally, the different characteristics can also be used in combinations other than those that have been represented and described.

Claims /10

1. Device for examining a container (1, 22) for surface defects, comprising: an illumination station for illuminating with light a preselected area (2, 21) of the container surface or at least a selected zone (2a, 2b, 2c) thereof, and a scanning station (9) with a light sensitive imaging array (10) for sweeping scanning light, which is reflected by the preselected area (2) or the at least one zone (2a, b, c), characterized in that the illumination station presents at least two light sources (6-8, 24-26) that emit differently colored light with a first respectively second color, the light sources (6-8, 24-26) are arranged in such a way that the area (2, 21) respectively the zone (2a, b, c) is irradiated by light of one light source (for example, 6, 24) from a first direction and by the light of the other light source (for example, 8, 26) from a second direction, and the directions are chosen in such a way that, in the case of an intact surface of the area (2, 21) respectively the zone (2a, b, c), reflected light of the first color appears at least partially at another place of the imaging array (10) than light of the second color reflected by the area (2, 21), respectively the zone (2a, b, c).

2. Device according to Claim 1 for examining an area (2) in the shape of a bottle mouth, characterized in that the light sources (6-8) are ring-shaped in design and light that is emitted by them is directed in such a way on the area (2) respectively a zone (2a, b, c) thereof that, on the imaging

array (10), in the case of an intact bottle mouth, concentric rings (14, 15, 16), which present different radii, appear in the different colors.

3. Device according to Claim 1 or 2 for examining an area (21) in the shape of a planar or arched container wall, characterized in that the light sources (24-26, 24a-26a) present a stripe-shaped design, and they are directed on the area (21) or a zone thereof in such a way that, in the case of an intact container wall, on the imaging array (10), parallel stripes (27, 28, 29) appear in the different colors.

4. Device according to one of Claims 1-3, characterized in that the light sources (6-8 or 24-26) can be /11
switched on simultaneously or temporally successively.

5. Device according to one of Claims 1-4, characterized in that the light of the first color is directed on a first zone (2a) and the light of the second color is directed on a second zone (2b) of the same area (2).

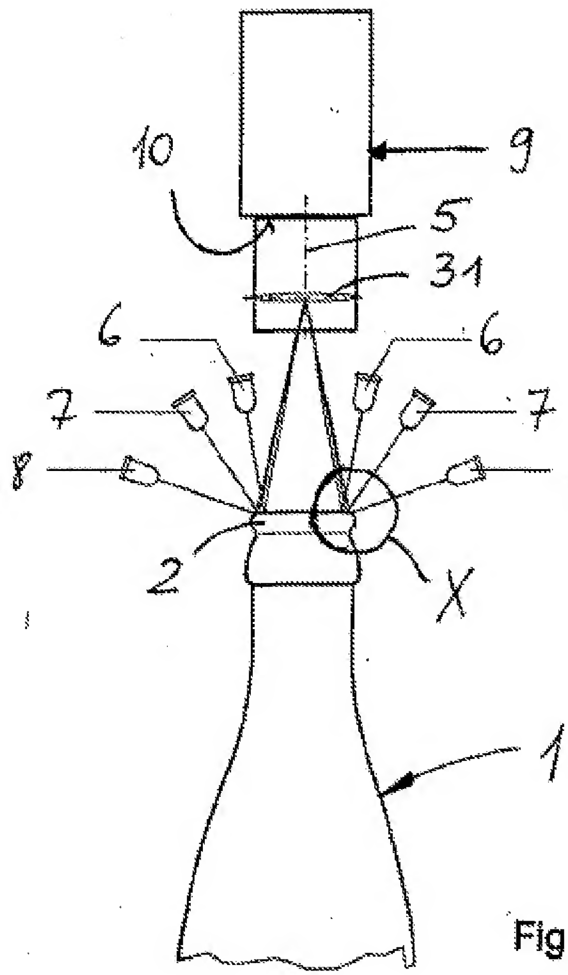

Fig. 1

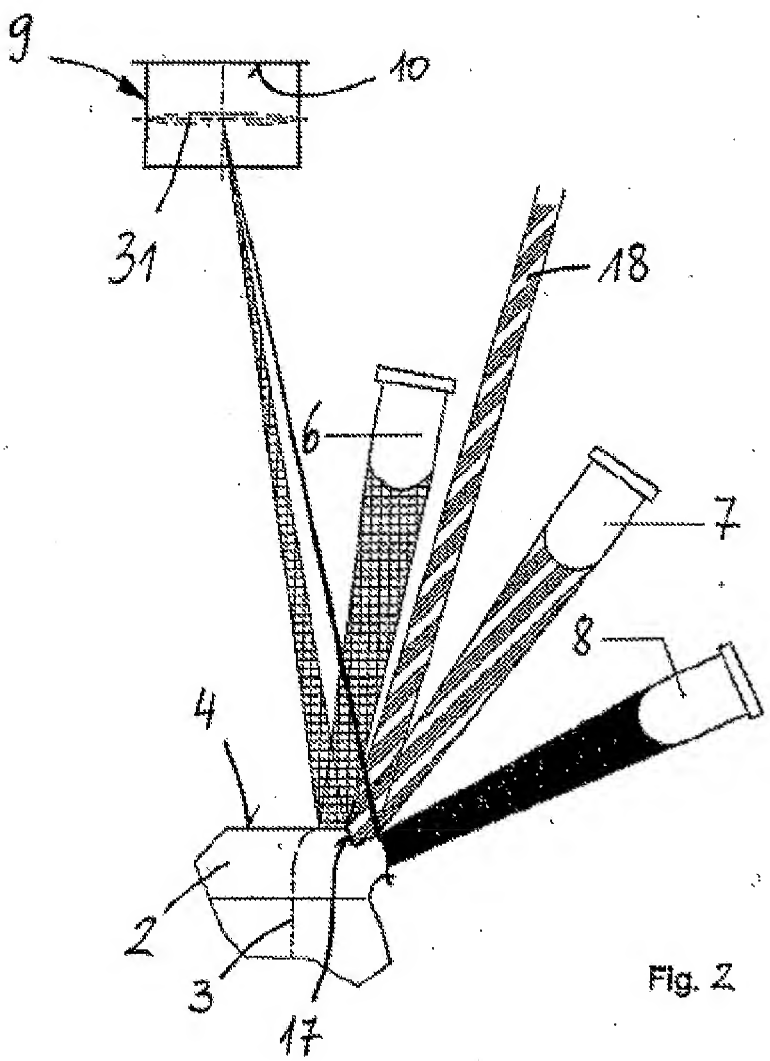

Fig. 2

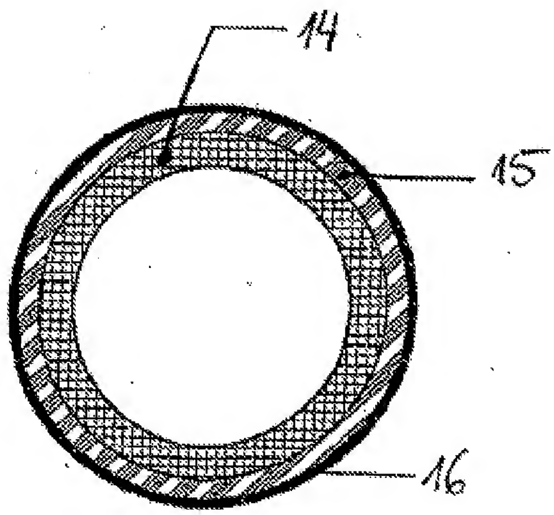

Fig. 3

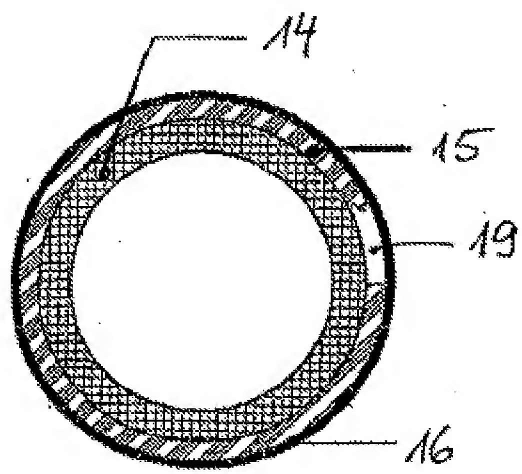

Fig. 4

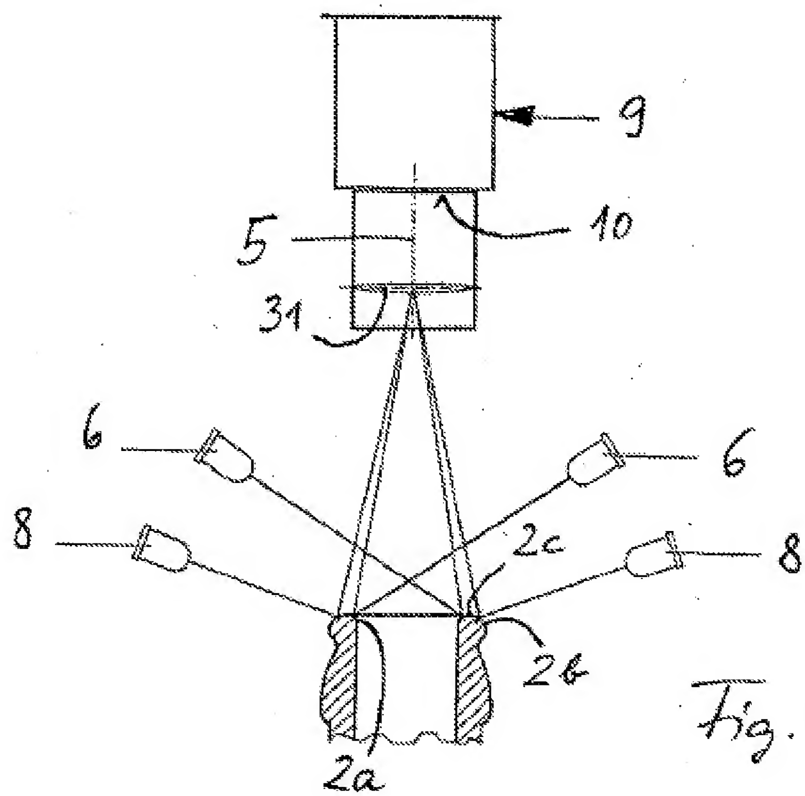

Fig. 5

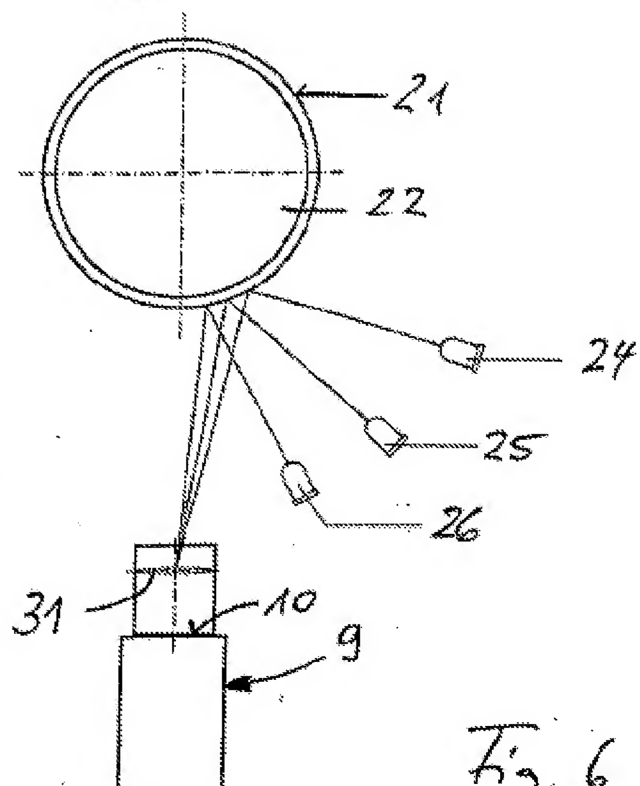

Fig. 6

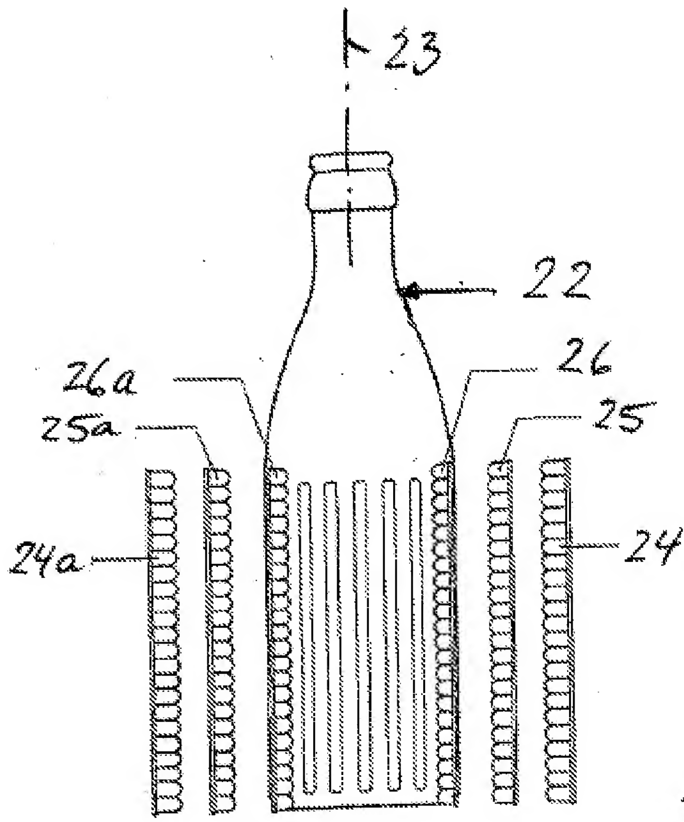

Fig. 7

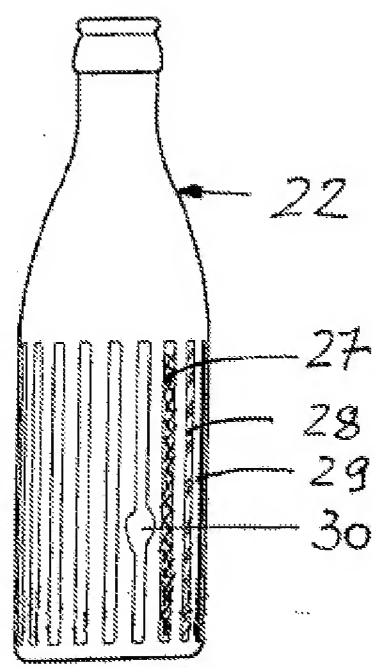

Fig. 8